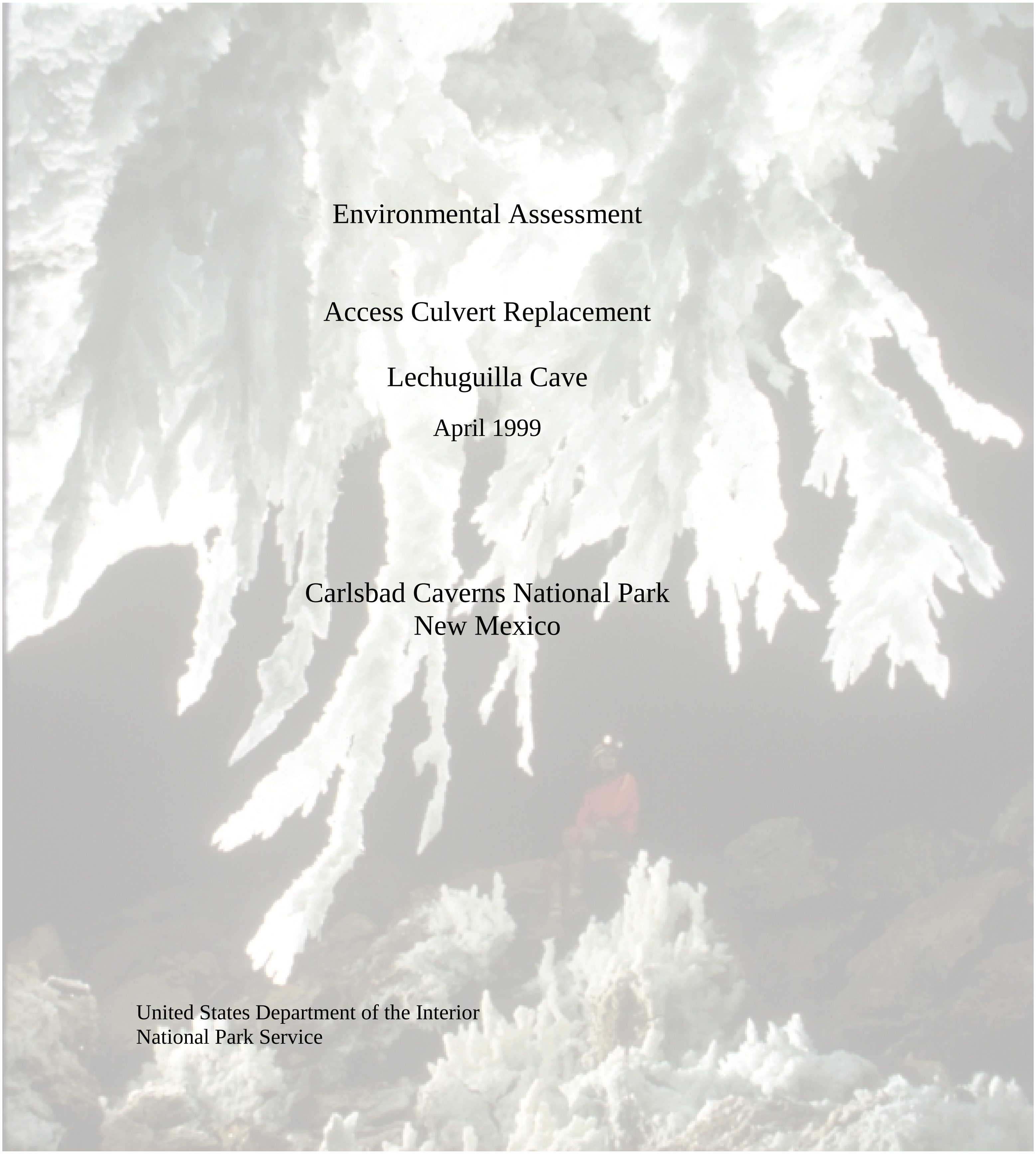

Environmental Assessment

Access Culvert Replacement

Lechuguilla Cave

April 1999

Carlsbad Caverns National Park
New Mexico

United States Department of the Interior
National Park Service

CONTENTS

PURPOSE AND NEED FOR ACTION

Carlsbad Caverns National Park (CCNP), through the Cave Resource Office, proposes to build a new access culvert into Lechuguilla Cave. The construction of this access would accomplish three goals: **security** of the cave, **safety** for those who enter, and long-term **environmental stability** for the entrance area of the cave. The design and implementation of the airlock will follow the National Park Service Management Policies (NPS 1988), Section 4:20, which state that….

> *Caves will be managed to perpetuate their atmospheric, geologic, biological, ecological, and cultural resources in accordance with approved cave management plans (action plans appended to approved resource management plans). Natural drainage patterns, air flows, and plant and animal communities will be protected.*
>
> *Developments, such as artificial entrances, enlarged natural entrances, pathways, lighting, interpretive devices, ventilation systems, and elevator shafts, will be permitted only where necessary for general public use and when development will not significantly alter any conditions perpetuating the natural cave environment or harm cultural resources. No potentially harmful development or use will be undertaken in, above, or adjacent to caves until it can be demonstrated that it will not significantly affect natural cave conditions, including subsurface water movements. Developments already in place above caves will be removed if they are significantly altering natural conditions.*
>
> *Caves or portions of caves will be closed to public use, or use will be controlled, when such actions are required for human safety or the protection of cave resources. Some caves or portions of caves may be managed exclusively for research, with access limited to approved research personnel*.

Lechuguilla Cave is a wilderness cave and is closed to the general public. However, this action is called for under the Cave and Karst Management Plan for Carlsbad Caverns National Park (CCNP 1995). In that plan, Lechuguilla Cave has been designated as a "Class 5-E-IV" cave. These classes are described in the plan as:

Management Class 5 caves, are closed to general use because they contain paleontological, geological, biological, archeological or other resources of special scientific value that would be easily altered, even by careful use of the cave. This does not exclude administrative entry for management purposes such as monitoring research activities, impacts upon the cave, or the rerigging of ropes for the safety of those who work in the cave. The extent of the cave makes it important that limited careful exploration, when accompanied by survey and inventory, be allowed to continue as part of this classification.

Resource Class E caves contain resources of scientific value that could and/or would be seriously disturbed by frequent visits , or by visits of cavers unfamiliar with the cave's unique resources.

Hazard Class IV caves are extremely hazardous from a structural standpoint.

In agreement to the **1988 Federal Cave Protection Act,** the location of Lechuguilla Cave has been purposely left out of this document. In accordance with the **Code of Federal Regulations Title 43-Public Lands: Interior Subtitle A-Part 37-Cave Management**, section **37.12 Confidentiality of cave location information**, paragraph (a), which states:

(a) Information disclosure. No Department of the Interior employee shall disclose information that could be used to determine the location of any significant cave or cave under consideration for determination, unless the authorized officer determines that disclosure will further the purposes of the Act and will not create a substantial risk to cave resources of harm, theft, or destruction.

Summary

Some of the problems with the existing cave entrance include:

1. The lid is unsealed and permits undesirable airflow into and out of the cave coincident with natural barometric pressure differentials.

2. The lid permits large exchanges of air during entry and exit by personnel coincident with natural barometric pressure differentials.
3. The lid security lock system is removed during expeditions and the cave is subject to unauthorized entry with the possibility of inadvertently locking an unauthorized entrant in the cave.
4. The lid and culvert opening have insufficient size diameter to facilitate ease of entry and exit by exploration personnel, equipment and possible future rescue operations.
5. The galvanized corrugated metal culvert has experienced surface and structural corrosion.
6. The unprotected steel ladder is severely corroded, on some rungs having lost half their mass, and constitutes a safety hazard.
7. The overburden falls onto the lid entrance and into the lower landing of the cave, requiring regular and frequent removal. The overburden also creates a safety hazard by the possibility of blocking the access lid, trapping personnel in the cave.
8. The cave environment is severely corrosive to all of the other entrance material including bracing and fencing. One of the galvanized braces has already broken under stress.

Security and Safety

The lid of the culvert has a latch and keyed padlock, which secures the handle from being turned to the open position allowing access. The present locking system is inadequate and the protection of Lechuguilla Cave could easily be compromised. The lid can only be locked from the outside, which means that during any maintenance, scientific or exploration expeditions, the lid to the culvert remains unlocked. Any unauthorized or illegal entry during one of these expeditions could conceivably end in dangerous entrapment of trespassers being inadvertently locked in the cave.

The existing Lechuguilla Cave access culvert consists of three parts: a locking lid at the top (Figures 1,2 and 8), covering a 24-inch diameter galvanized road culvert with a ladder (Figure 3), leading to a braced half-culvert with a ladder and fencing at the bottom (Figure 4). This entrance structure was installed using new materials in May of 1986. Two natural openings permit access to the cave’s entrance chamber above the culvert (Figure 13). The right chimney opening is used as the access to the culvert with the aid of a rope. The left opening is discussed later. The hinged circular steel lid locked with a padlock covers the opening of the 26-foot long culvert. The culvert is jointed and bends at the last third of its length.

Limestone bedrock abuts the top length of the culvert. Breakdown (fist sized to very large boulders) and alluvial fill surrounds the remainder of the culvert. A similar half-culvert section with fencing (Figure 5) secured to the bottom holds the lower portion of the breakdown and fill away from the ladder landing for clear access. Breakdown and fill also lies above the entrance lid forming a funnel, and below the culvert’s lower end, forming a cone of debris. This lower conical debris pile is the result of the deposition from the unstable breakdown and fill that surrounds the culvert above. Breakdown and alluvial fill in both the funnel and conical areas are sloped at nearly 45 degrees, permitting some slope failure with minor disturbances. The total amount of overburden directly above, around, and below the entrance lid and culvert is estimated to be approximately 80 cubic yards of material. Limestone bedrock surrounds and supports the overburden along the culvert passage. A steel ladder is secured to the culvert and half-culvert for safe travel from the upper to the lower landings. Galvanized steel fence posts provide bracing and support for the culvert, fencing and ladder. All of the metals in the structure exhibit significant corrosion. The ladder is severely corroded, having lost over half of its mass. (Figure 6).

Directly above the lid of the culvert, approximately 15 vertical feet, is the left access to the entrance chamber. This vertical access is a major concern, and may present a severe safety hazard. During infrequent desert downpours, sediment and rocks, sometimes very large rocks, are dislodged and fall on to the lid of the culvert. Prior to entry, this causes the inconvenience of digging debris from around the lid. However, after the entry by an expedition, it could conceivably trap personnel in the cave.

Environmental Stability

Lechuguilla Cave exchanges air at the culvert whenever barometric pressure changes. When external barometric pressure drops, the cave exhales (blows out); on the other hand, when the barometric pressure rises, the cave inhales (sucks in). During these barometric pressure changes, winds through the culvert have been measured in excess of 60 miles per hour. Ideally, the culvert lid should seal totally; allowing air exchange *only* through the breakdown and rubble as it was before the initial breakthrough in 1986. It is speculated that the present volume of air exchanging through the existing culvert, even with the lid closed, may cause an unnatural drying effect upon the upper passage environments.

Due to the scientific significance and worldwide notoriety of Lechuguilla Cave, major expeditions will continue. To protect the cave resources and insure safety of exploration teams in the future, a properly designed airlock access culvert system should be installed.

SIGNIFICANCE AND HISTORY

Lechuguilla Cave is a world class cave, and arguably the most significant cave discovery in the 20th Century. Although the volume of air hissing through the alluvial backfill and breakdown at the dig site was evidence of the possibility of extensive passage beyond, nobody in 1986 had a clue that Lechuguilla would have a profound influence on the entire world caving community.

Lechuguilla Cave, has been known at least since 1914 when it was mined for guano. John and Cad Ogle soon recognized the inferior quality of the guano, and the mine was abandoned shortly thereafter. However, air hissing up through the rubble in the floor didn't go unnoticed by the miners.

Throughout the years, different organized groups applied for and received permits from the National Park Service to dig for the hidden passages of Lechuguilla. On May 26, 1986, a group of cavers from Colorado broke through into the vast labyrinth of the Lechuguilla

Cave we know today.

Descending through the alluvial fill and breakdown of the dig site was quite dangerous, and by week's end, May 30-31, a 16-foot-long, 24-inch diameter road culvert, a 10-foot-long half culvert, along with a ladder was placed through the rubble for safety. A security gate and padlock were also placed on the culvert to prevent unauthorized entry.

The only change that has been made to the culvert since its installation was the addition of a security lid in 1989. Although security was certainly a priority, the main purpose of the lid was to minimize the high volume of air exchange through the culvert.

Prior to the breakthrough, Lechuguilla's total mapped passage was approximately 200 feet long, and 75 feet wide at its widest point. Today, after several thousand man-hours, and countless expeditions, Lechuguilla is both the deepest limestone cave at 1,567 feet deep, and the third longest cave in the United States with 100.85 miles of mapped passage as of March, 1999.

The enlightenment of scientists to the vast microbial world of caves is a direct result of ongoing research in Lechuguilla. Dr. Larry Mallory has identified several microbes from Lechuguilla Cave that may be significant in the treatment of cancers. National Aeronautics and Space Administration (NASA) is investigating the microbial life found in Lechuguilla and speculating whether life on Mars may be similar. Diana Northup and Dr. Penny Boston are studying the microbial community to determine impacts from human encroachment.

Many speleothems unique to Lechuguilla have been identified. Giant selenite chandeliers, up to 16 feet in length, are found in the Chandelier Ballroom. Subaqueous helictites, biothems (biologically influenced speleothems), and rusticles, along with 32 positively identified minerals, are also found in Lechuguilla. Lechuguilla Cave is truly a marvel for speleologists and cave enthusiasts throughout the world.

AFFECTED ENVIRONMENT

Wilderness Resources

Lechuguilla Cave is in Congressionally Designated Wilderness. The park is currently updating its Backcountry/ Wilderness Management Plan. All caves of the park, including Lechuguilla, that are located in wilderness are managed as wilderness areas. CCNP is managing its wilderness according to the NPS Wilderness Preservation and Management Guidelines (NPS 1998, draft), which state:

> *In protecting wilderness character and resources and in all management actions affecting these resources, the National Park Service will apply the "minimum requirement" concept procedures… Superintendents, in accordance with the wilderness management plan, will apply this concept in determining: (1) whether or not the project is actually needed in wilderness and , (2) the techniques and equipment necessary to accomplish the needed project… Potential disruption of wilderness character and resources and applicable safety concerns will be considered before, and given significantly more weight than, economic efficiency and convenience. If a compromise of wilderness resources or character is unavoidable, only those actions that have localized short-term adverse impacts will be acceptable.*
>
> *Administrative use of motorized equipment or mechanical transport including motorboats and aircraft, will be authorized in accordance with the parks wilderness management plan only (1) if determined by the superintendent to be the minimum requirement needed by management to achieve the purposes of the area as wilderness, or (2) in emergency situations…*

The use of power-driven equipment and helicopters under any alternative for this project would be approved on the basis of the minimum tool analysis contained in the Environmental Impacts Section.

Geological Resources

The limestone in the entrance of Lechuguilla Cave lies in the Seven Rivers geologic formation except for the first few feet, which are in the Yates formation. Like many caves in the Guadalupe Mountains, Lechuguilla Cave has a vertical, fissure type entrance requiring a 50-foot rappel. The landing and floor of the entrance room is strewn with alluvial backfill and small breakdown. The walls of the entrance pit are solutioned bedrock. The culvert area is the access to the solution passage leading to the main portions of Lechuguilla Cave and is composed of alluvial fill, and small to medium sized breakdown. The ceiling and one side of the dig area is solid solutioned bedrock.

Paleontological Resources

Lechuguilla Cave is a natural “pit-fall”, and remains of many now-extinct animals may be lying in the breakdown and rubble.

Biological Resources

Lechuguilla Cave is geologically unique; therefore, it seems possible that it also harbors unique biological phenomena. Research is continuing on this question. Concurrently, preservation of the habitat for cave-dwelling organisms is important.

The habitats of the entrance pit are different from the deep cave in amounts of light, air circulation, and organic matter. In the entrance, moisture content varies between the relatively wet area at the bottom of the extension of the entrance pit to some fairly dry dusty sediments in the alcove area. Organic matter is present. Most of the invertebrates were found in the moist areas. Inside the cave, despite the environment being considered “extreme” (“extreme” meaning no light, high humidity, constant temperature and little or no organic input) current research indicates that the diversity of microbial life found in Lechuguilla is extremely high. Dr. Larry Mallory has compared the diversity in the cave to that of a tropical rainforest.

The primary organisms in Lechuguilla Cave are invertebrates and microorganisms (fungi and bacteria). Vertebrates do occur (mainly toads, lizards, and snakes) at the bottom of the entrance fissure, but they have accidentally fallen into the cave and it is not their prime habitat.

Invertebrates in the entrance pit include “a variety of accidental species (beetles, flies, ants and grasshoppers) and several trogloxenic, troglophillic and troglobitic species (camel crickets, rhadine beetles, mites, collembolans, and millipedes)” (Northup 1992). The main population of invertebrates is at the bottom of the pit adjacent to the entrance chamber, an area that would not be affected by this project.

Inside the cave, at least six insect species, 37 fungal species, and seven bacteria species have been positively identified. Dr. Mallory has isolated at least 1,000 native strains of microbes that have not yet been identified to species.

Lechuguilla Cave appears to be a rich resource of cave bacteria. All identified so far are classified as chemoheterotrophs [bacteria that utilize reduced carbon as their energy source] (Northup 1992). Many of them are unique to this cave, and more than likely, new species will be identified. Fungal spores are found in areas where cavers have been and where wind currents are strong.

Because the possibility exist that the fungi and bacteria may form a unique relationship in the corrosion residue, and possibly on the other speleothems, it is important to preserve the habitat as much as possible.

According to Northup (1992), microorganisms that gain entry into the subterranean environment use several routes. Studies have noted that air currents, when caves are “sucking”, carry in many microorganisms, although this is not believed to be an important avenue in the Lechuguilla Cave situation. Many microorganisms seep down through the rocks between the cave and the surface through fissures, porous rocks, and tiny voids.

Because of its long isolation from humans, and the highly controlled nature of current visitation, the cave offers many opportunities to study these organisms in their natural habitat. Restoring natural airflow is an important aspect of protecting them.

Endangered and Threatened Species

The surface around the entrance area of Lechuguilla was surveyed on March 19, 1999, for rare , endangered, or threatened species, including the federally threatened Lee's pincushion cactus. None was found. (R. Beymer, 1999)

Wetlands

There are no wetlands in the entrance area of Lechuguilla Cave.

Cultural Resources

There are remnants from the old guano mining days at the bottom of the entrance drop that consist of old 2X4 wood, wire and wire mesh.

ALTERNATIVES

Three alternatives are described in this section. The NPS preferred alternative is Alternative B.

<u>ALTERNATIVE A - Three Concrete Walls</u>

Description: This alternative would involve installing three steel reinforced concrete walls (4-inch thick each): two walls enclosing the right natural chimney opening, providing airtight doorways, and the third wall permanently closing the left natural opening and creating a tight airlock above the top of the existing culvert landing (Figure 9).

The first entrance wall would have a circular stainless steel hinged door (36-inch diameter) and the second wall would have a rectangular hinged plastic door (36-inch width by 48-inch height) (Figure 10). The outer circular door would have a lock assembly to permit locking/unlocking from either side. . Two stainless steel ladders would be installed to permit access for the upper landing (now accessed by rope or free climbing) and the lower landing (in place of the existing culvert and ladder assembly).

The existing culvert, ladders, fencing and bracing, as well as all breakdown and alluvial fill would be removed.

The breakdown and alluvial fill would be deposited in the original dig depressions in the entrance chamber above. The majority of alluvial fill would be left at the lower landing based on acceptable foot print size and side slope, therefore reducing the removal and disposal effort. Paleontological remains may exist in the breakdown and alluvial fill and require consideration for assessment and removal during the construction process.

This alternative would involve use of power drills in the cave entrance, helicopter delivery of sling loads of equipment, the use of a power driven cement mixer on the surface near the cave entrance, and the addition of permanent structures in wilderness (three concrete walls).

Engineering analysis and evaluation: The proposed design would satisfactorily correct the problems identified in the *Purpose and Need* section. The design is safe, reliable and constructable. Large boulders may not be feasibly removed to the floor area above, however, could be moved to a safe location. A system of breakdown and alluvial fill removal would require a pulley system with as many as five workers at one time working approximately a total of 200 person-hours. Inflatable balloons (3 to 4-foot diameter) would be used in a tight constriction of the passage below the present culvert to reduce air movement during construction.

<u>ALTERNATIVE B - Barred Gates and Airtight Door</u>
(Preferred Alternative)

Description: A stainless steel barred gate would be installed enclosing an airtight stainless steel circular hinged door (36-inch diameter). A stainless steel barred gate would permanently close the left opening to the top of the existing culvert landing to prevent access to the PVC tubing.(Figure 12). A PVC pipe (42-inch diameter) would connect to the stainless steel doorway using a stainless steel bulkhead connecting the door to the pipe and an airtight plastic door on the lower end, providing an airlock (Figure 11). The lower pipe would extend well beyond the limits of the breakdown and alluvial fill. The outer circular door would have a lock assembly to permit locking/unlocking from either side. The existing culvert, ladders, fencing and bracing, would be removed from the cave entrance. Only the breakdown and alluvial fill necessary for the installation of the pipe is removed and disposed of in the depression from the original digging sites in the entrance chamber above. Once the pipe is installed, the breakdown and alluvial fill would be replaced around the pipe and the entrance returned to its original contours. One continuous stainless steel ladder would permit access for the upper landing (now accessed by rope or free climbing) and the lower landing (in place of the existing culvert and ladder assembly) (Figure 11).

This alternative would involve use of power drills in the cave entrance, helicopter delivery of sling loads of equipment, the use of a power driven cement mixer on the surface near the cave entrance, and the addition of some permanent structures (one concrete wall and a slightly longer culvert).

Engineering analysis and evaluation: The proposed design would satisfactorily correct the problems identified. The design is safe, reliable and constructable. Large boulders will not be feasibly removed to the floor area above. A system of breakdown and alluvial backfill removal will require a pulley system with as many as five workers at one time working approximately a total of 100 person-hours. A precise survey locating the limits of the limestone bedrock is required to accurately determine the proper location. Inflatable balloons (3 to 4-foot diameter) would be used in a tight constriction of the passage below the present culvert to reduce air movement during construction.

ALTERNATIVE C – No Action

Description: Under alternative C the present culvert and surrounding alluvial backfill would be left intact. The present 24-inch galvanized steel road culvert, locking lid and ladders would remain as is.

Engineering analysis and evaluation: The present access to Lechuguilla Cave consists of a 24-inch road culvert with a locking lid, extending down through alluvial fill and breakdown. There is a mild steel ladder that runs the length of the interior of the culvert to permit safe travel to the passage below.

Under the no action alternative, no improvements to the present culvert and alluvial backfill would be made. The situation would remain unsafe for cavers, restrict future rescue operations, and still expose the cave to unauthorized entry, resource damage, and the drying effects of air exchange.

ENVIRONMENTAL IMPACTS

Wilderness Impacts--Minimum Tool Analysis

Since Lechuguilla Cave is located within congressionally designated wilderness, there is no non-wilderness alternative site for this project. Battery-powered drills would be the minimum tool under both **Alternatives A and B** for anchoring concrete walls. Bolts placed in holes drilled with battery-powered drills are much safer due to better accuracy and depth. Bolts placed in hand drilled holes have a lot of play and have more room for failure.

For **Alternative A or B**, all cement would be mixed on the surface in a gasoline power-driven cement mixer to minimize impacts to the wilderness resource. A power mixer would be the minimum tool because it would reduce resource impacts by decreasing slopping and spilling--mixing would be done in a confined barrel. The cement would then be lowered into the cave in sealed buckets on a block and tackle system.

All major construction materials--especially PVC tubing, cement mixer, cement, rebar, and water--would be sling loaded to the entrance of the cave by helicopter. Because the helicopter would not land in wilderness, and would result in only a short-term adverse impact, it is considered the minimum tool for transport. The use of motor vehicles for transport to the site would result in substantial impact because of driving in wilderness and it was rejected for that reason.

Some new man-made structure would be added to wilderness under both these alternatives. For **Alternative A**, this would mean three concrete walls inside the cave entrance. For **Alternative B**, it would mean one concrete wall and a slightly longer culvert. Some new structure is necessary in order to protect the safety of people entering the cave, improve natural airflows, and continue to manage Lechuguilla Cave according to the park's management plan. **Alternative A** would have more man-made structures than **Alternative B** and would require more drilling to anchor the concrete walls.

Under **Alternative C** there would be no new wilderness impacts, although the existing culvert would remain in place.

Geological Impacts

<u>Alluvial fill</u>

In order to replace the present culvert, the only access to Lechuguilla

Cave, the surrounding area of alluvial fill must be removed. Most of this fill has been disturbed previously during the digging project and placement of the original culvert.

Should **Alternative A** be selected, all the alluvial fill in the excavated area would be permanently placed in depressions from previous digs in the main entrance room above.

Should **Alternative B** be selected, only the alluvial fill necessary for construction would be removed from the excavated room and temporarily placed in depressions from previous digs in the main entrance room above. Once the construction is complete, all the removed alluvial fill would be returned to the excavated room surrounding the new PVC tubing.

Should **Alternative C** be selected**,** there would be no immediate impact, however, the culvert would eventually collapse and the fill would settle.

<u>Disturbance to Bedrock</u>

Drilling into bedrock would be kept to a minimum if either **Alternative A** or **B** is chosen.

Alternative A would require drilling several holes into bedrock for the placement of rebar in two different places in the entrance chamber. Although the placement of rebar would be held to a minimum, it would be necessary to create stable cement walls (Figures 9 and 10). There are no significant features in the entrance area that drilling would have an impact on.

Alternative B would require occasional drilling into bedrock (fewer holes) to stabilize the PVC tubing that would take the place of the present culvert.

Alternative C would have no effect on the bedrock.

Paleontological Impacts

The alluvial fill, which may contain paleontological resources, would be moved under **Alternative A** or **B**. A park-designated paleontologist would be available to identify and properly record any paleontological resources found during the alluvial fill excavation. All significant paleontological resources would be cataloged and stored in the park's museum collection, therefore scientific knowledge would be enhanced.

Alternative C would have no impact.

Biological Impacts

Under **Alternatives A** and **B** there would be short-term disturbance of soil and some vegetation on the surface. The temporary equipment storage and cement mixing site near the entrance would cover 30 square feet of area. Every effort would be made to minimize plant damage and soil compaction.

Under **Alternative C** there would be no surface impacts.

The removal of the alluvial fill (**Alternative A** and **B**) would temporarily disturb the habitat for certain endemic species of invertebrates that live in the entrance area of Lechuguilla Cave. This is an unavoidable short-term impact that may result in some mortality. Under **Alternative C**, there would be similar impact upon collapse of the culvert, when that occurs naturally.

Impacts to Endangered and Threatened Species

Since there are no endangered and threatened species in the area, there are no impacts.

Impacts to Wetlands

There are no wetlands in the entrance area and therefore no impacts.

Impacts to Cultural Resources

There will be no cultural resource impacts.

LIST OF PREPARERS

Jason M. Richards, Cave Specialist, CCNP
Renee Beymer, Resource Management Specialist, CCNP
Mark Bremer, Civil Engineer, CCNP

LIST OF PERSONS CONSULTED

Dale Pate, Chief Cave Specialist, CCNP
Stan Allison, Physical Science Technician, CCNP
Tom Bemis, Electronics Mechanic, CCNP

Diane Dobos-Bubno, Resource Management Specialist, CCNP
David Roemer, Resource Management Specialist, CCNP
Gary Vequist, Chief Ranger, CCNP
Jim Werker, Sandia National Laboratories
Jeff Denny, Museum Curator, Cultural Resource Specialist, CCNP

REFERENCES

Carlsbad Caverns National Park (CCNP). 1995. Cave and Karst Management Plan, available at CCNP.

Mallory, Larry. 1995. Numerical Taxonomic Comparison of two Freshwater Microbial Communities in Lechuguilla Cave, CCNP

Northup, Diana. 1992. Lechuguilla Cave Biological Inventory.

National Park Service (NPS). 1998. DRAFT Reference Manual #41:

Wilderness Preservation and Management. Available at CCNP.

NPS 1988. Management Policies, available at CCNP**.**

Code of Federal Regulations Title 43-Public Lands: Interior Subtitle A-Part 37-Cave Management

NPS. 1995 (Feb. 16). Memorandum from Southwest Regional Director on Use of Power Drills in Lechuguilla Cave, on file at CCNP.

PHOTO AND ILLUSTRATION CREDITS

Chandelier Ballroom (background)
Roland Vinyard

Figures 1 through 6
Stan Allison

Figures 7, 8 and 13
Jason M. Richards

Figures 9 and 10
Jim Werker

Figures 11 and 12
Mark Bremer

Figure 1
The lid of the culvert, latching handle, and counter weight on the left.

Figure 2
Looking into the culvert with the lid open.

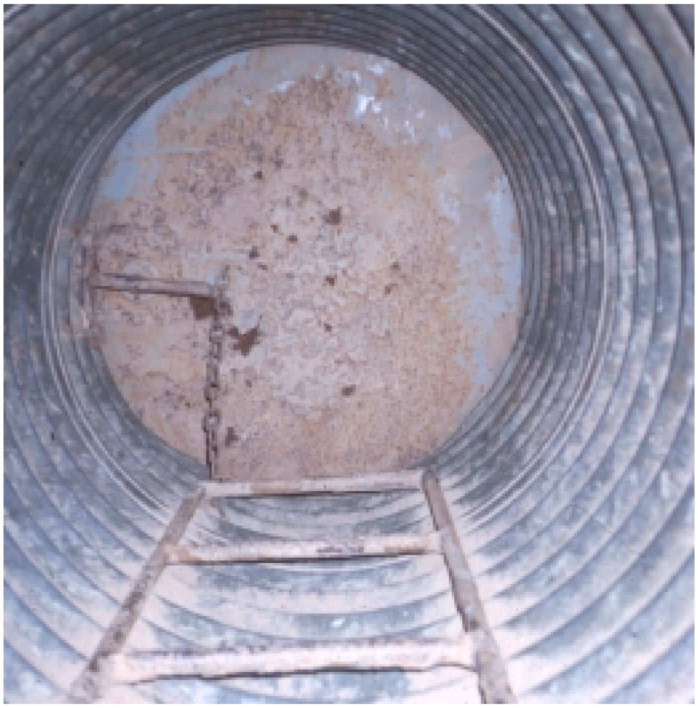

Figure 3
Inside the culvert looking at the closed lid.

Figure 4
Bottom of the “half culvert”. Note the broken support lying below and to the left.

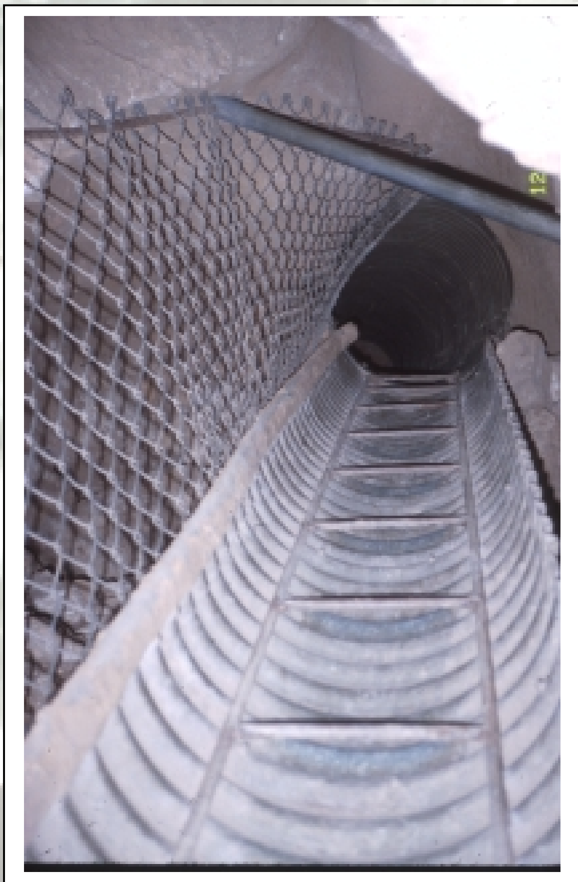

Figure 5
The fencing on the left supports breakdown from collapsing on cavers.

Figure 6
The exfoliating rust on the rungs of the ladder.

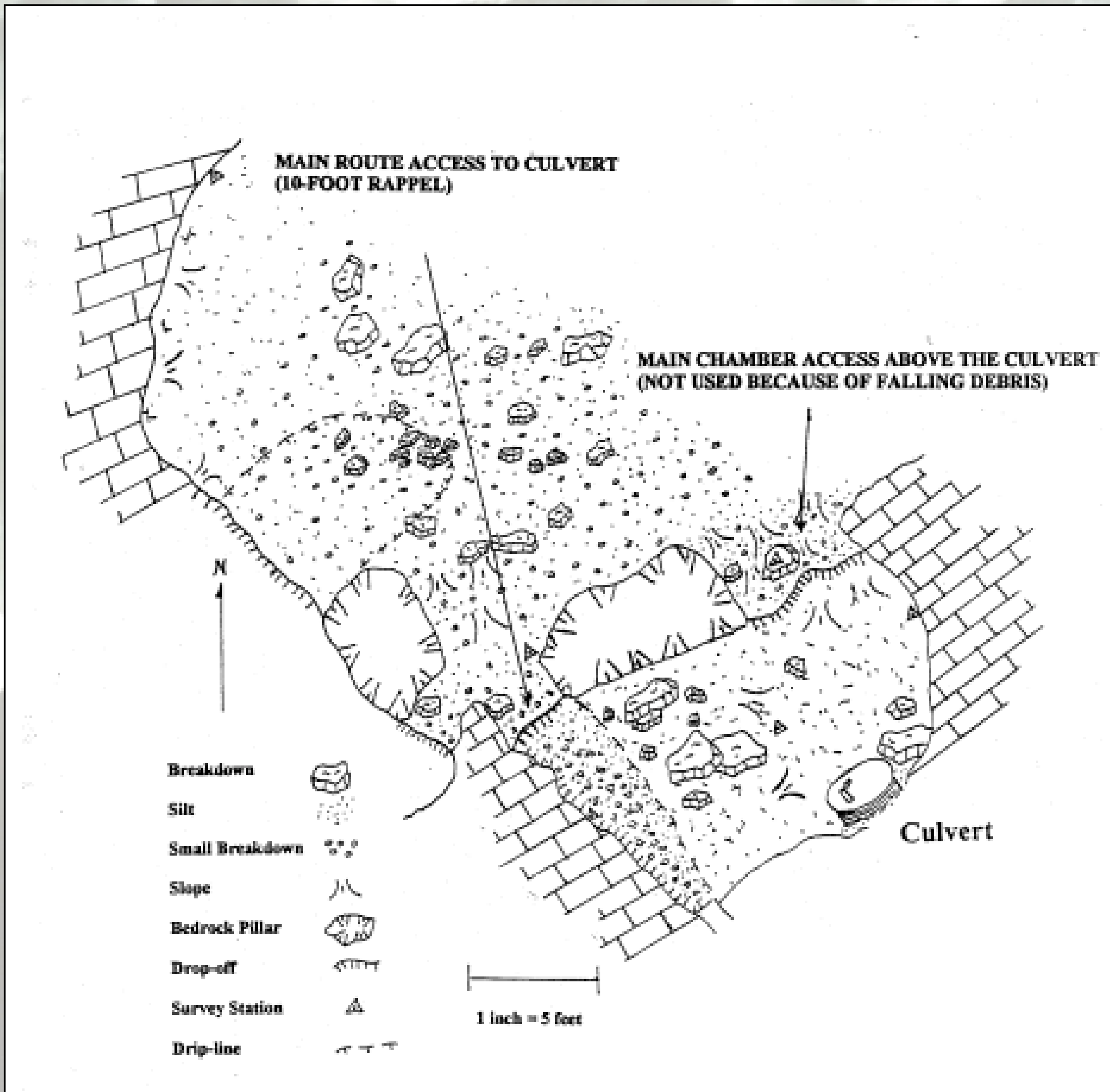

Figure 7
Plan view of the entrance floor and the lower culvert area.

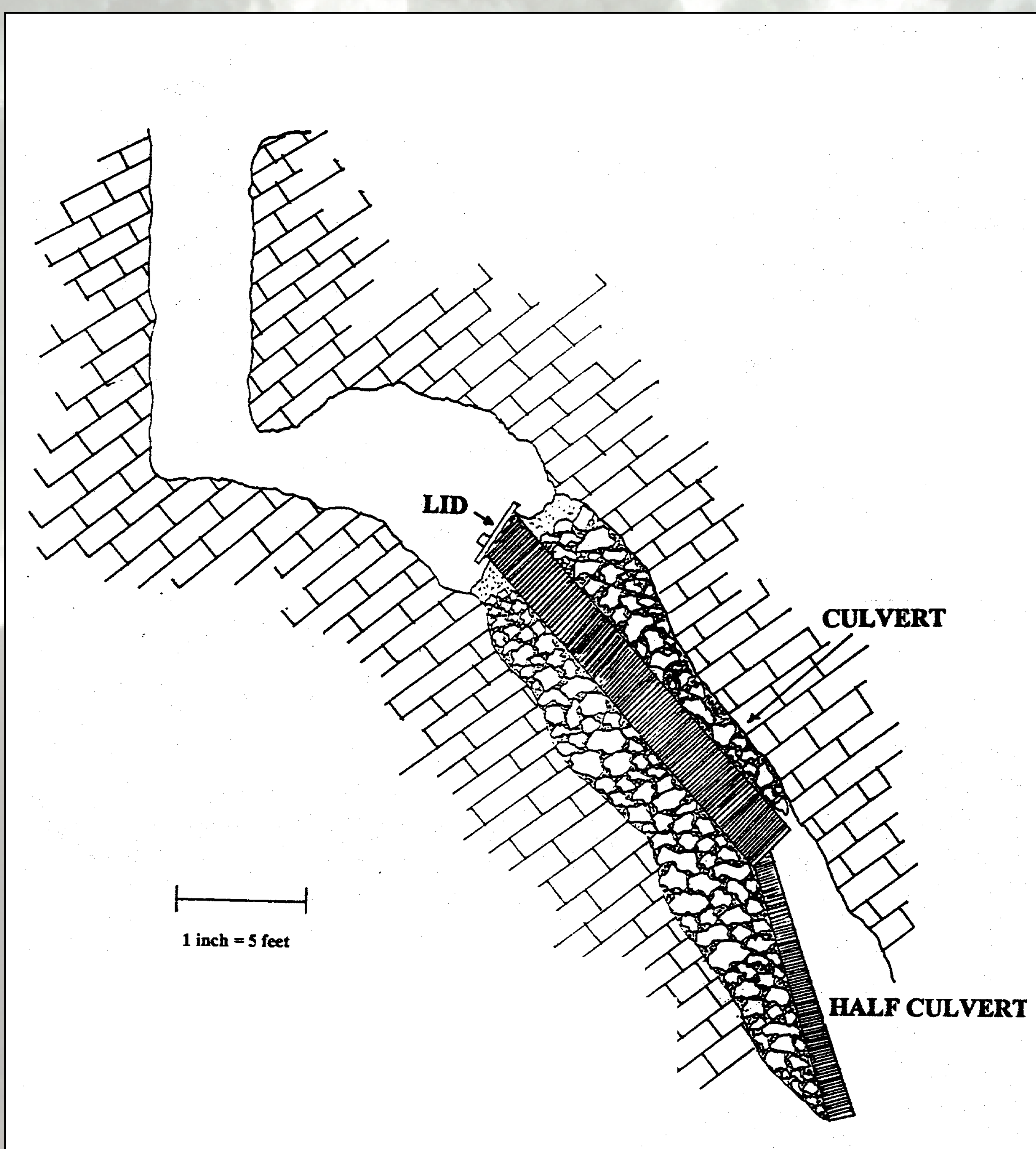

Figure 8
Profile of the present access culvert and its relation to bedrock and alluvial backfill.

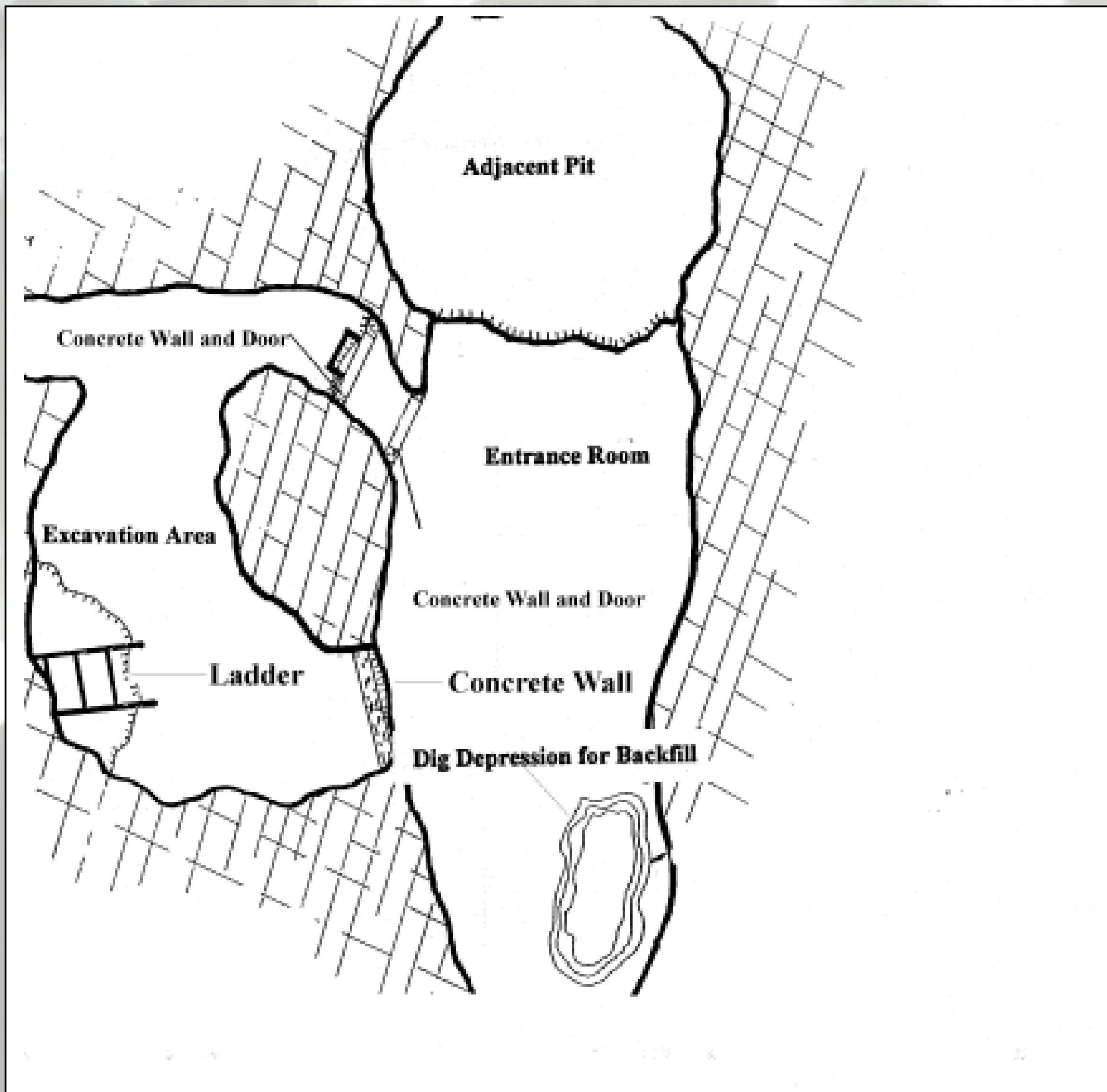

Figure 9
Alternative A
Plan view of entrance chamber showing the locations of the proposed permanent cement and rebar airlock walls.

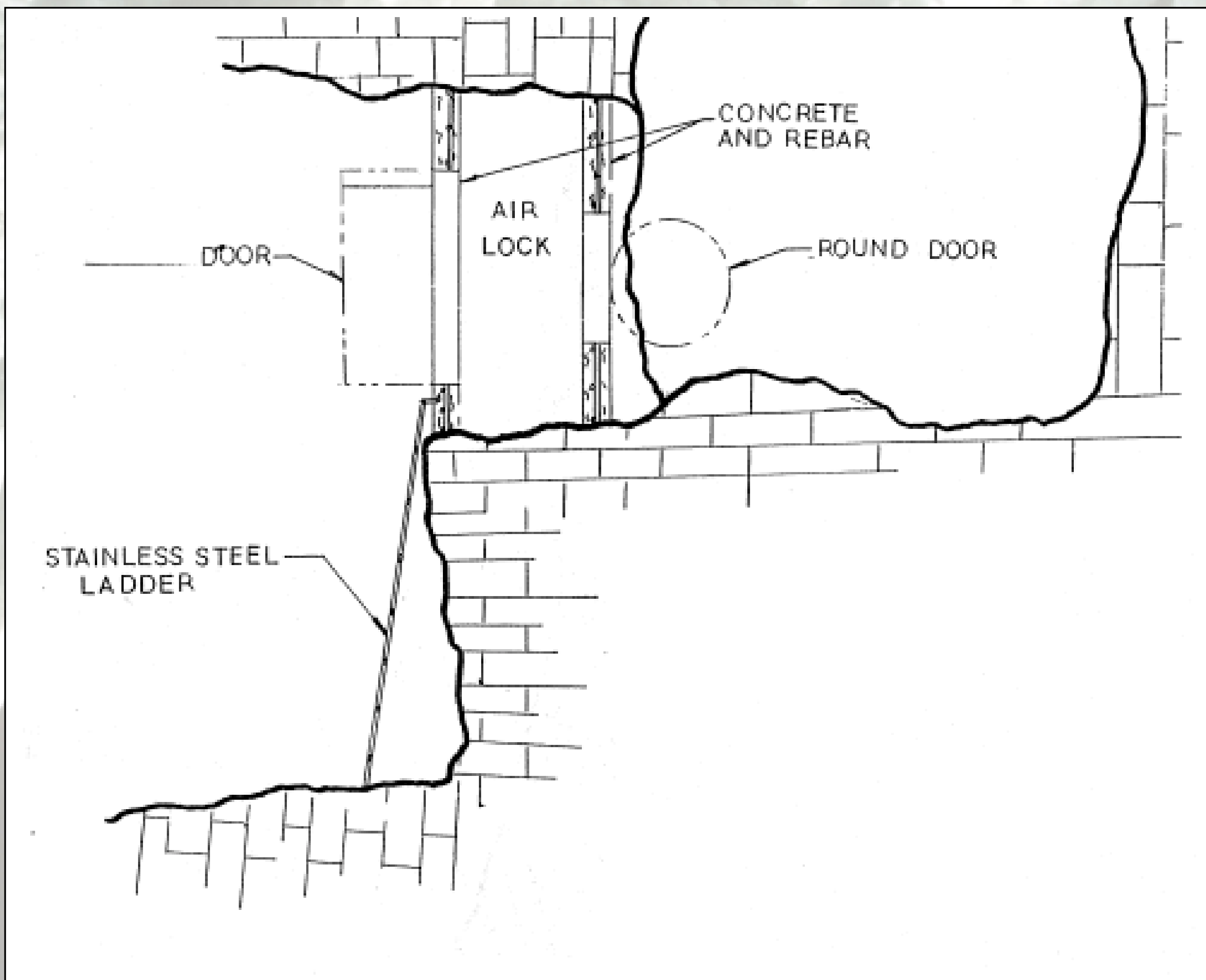

Figure 10
Alternative A
Profile view of the double airlock and ladder after the alluvial backfill has been removed.

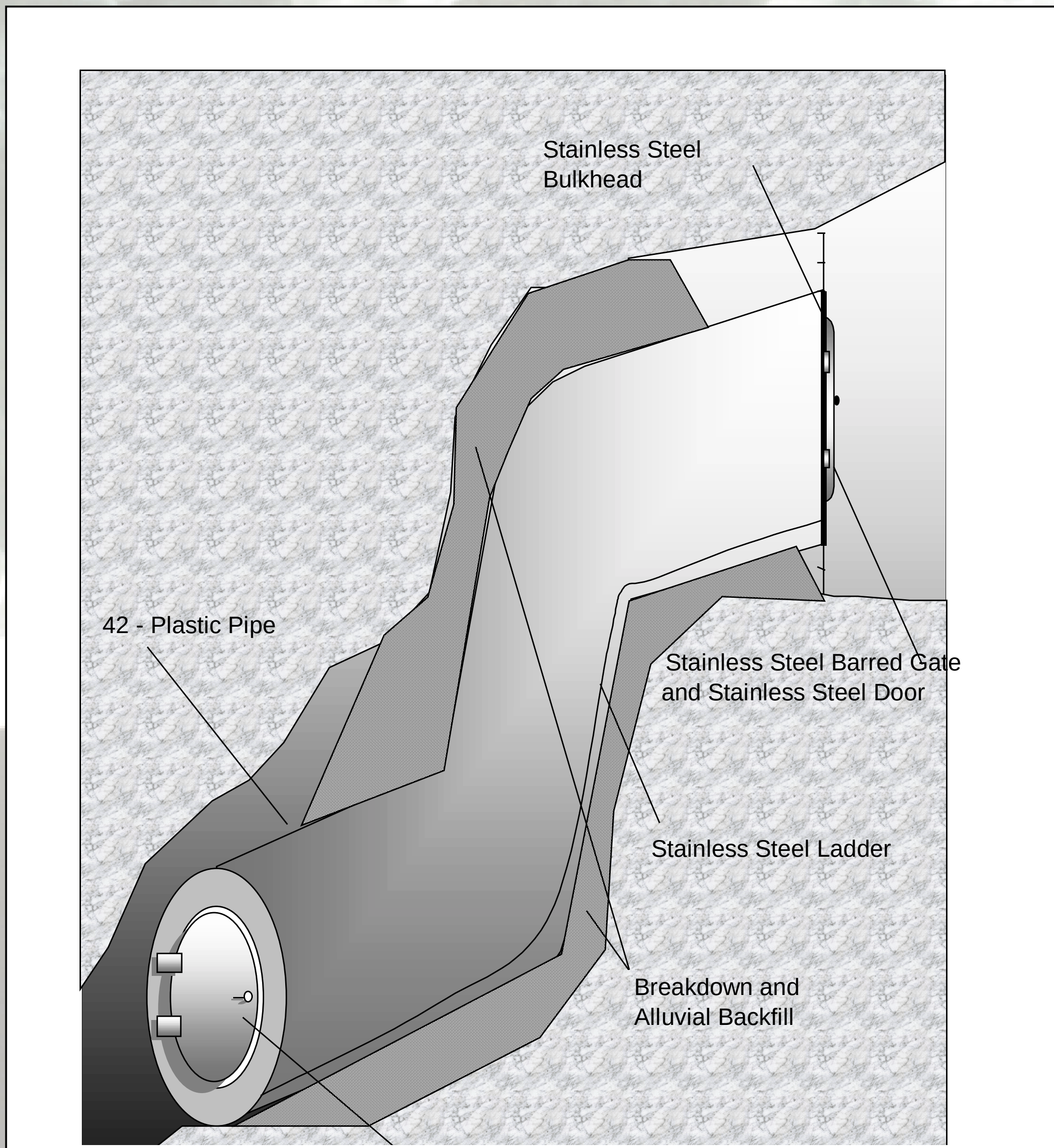

Figure 11

Alternative B. Profile of 42-inch PVC tubing with stainless steel airlock doors at the top and the bottom.

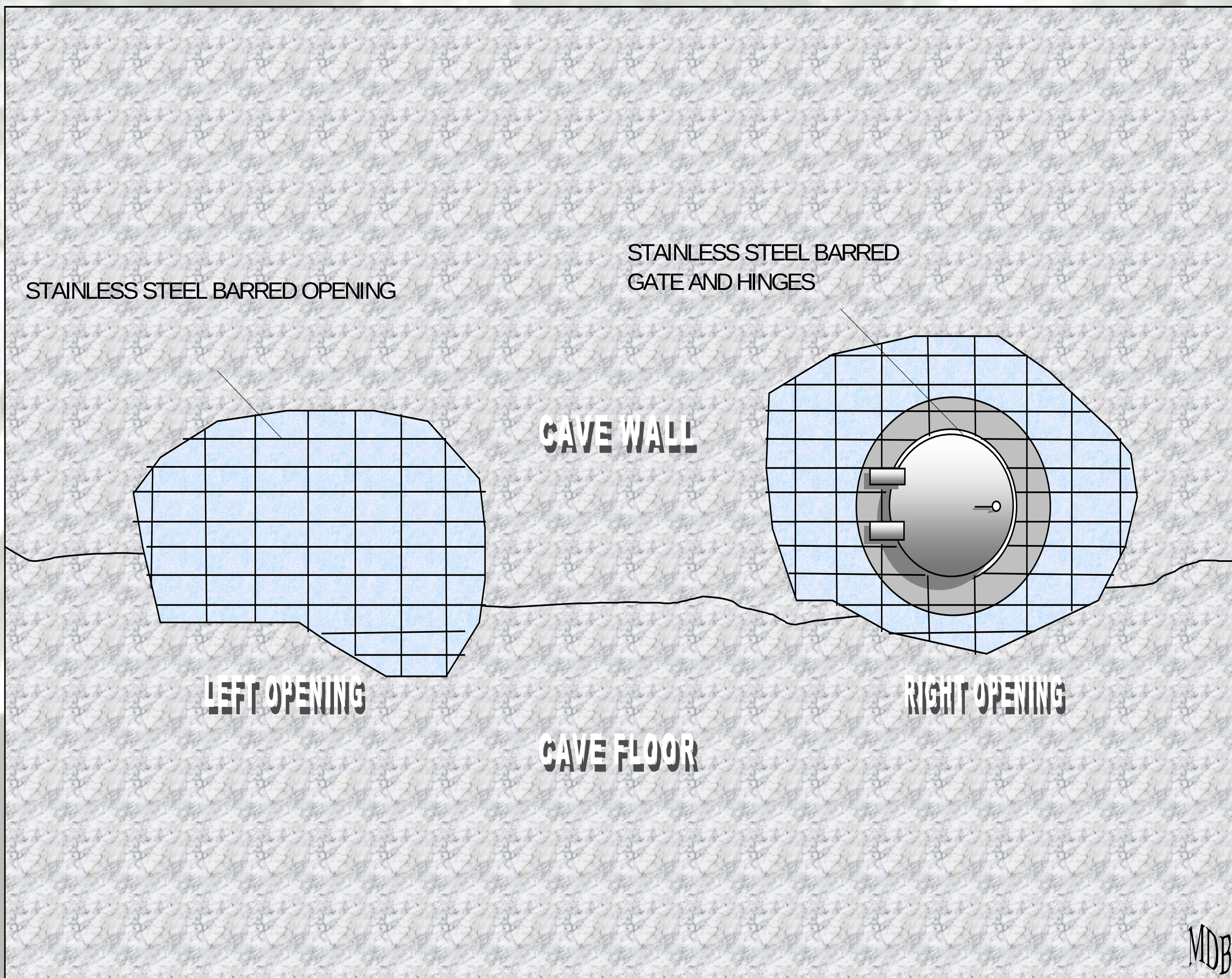

Figure 12
Alternative B
Plan view of the entrance chamber showing the right and left access to the culvert area. The right opening, formerly known as the nuisance drop will be where you enter the PVC tubing. The left side will be permanently sealed off to prevent access to the PVC tubing.

Figure 13
Photograph of both accesses to the culvert area. The access on the right is the one used, and the one on the left is directly above the culvert.